AD-A097 937 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 20/4
H0011- KINEMATIC VISCOSITY OF WATER FOR TEMPERATURES IN THE 32--ETC(U)
JUN 78 M T HEBLER, B J BROWN

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ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM: HDC11 - Kinematic Viscosity of Water for Temperatures in the 32-100°F Range or 0-38°C Range

PROGRAM NO.: 722-F3-R0-00K

PREPARING AGENCY: Hydraulic Analysis Division, Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, MS 39180

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM	
		PHASE	STAGE
Martin T. Hebler Bobby J. Brown	Aug 1973 Documented June 78	Origin	Operational

A. PURPOSE OF PROGRAM: To compute the kinematic viscosity of water for temperatures in the 32-100 degree Fahrenheit range or 0-38 degree Celsius range.

References:
(1) HDC Chart 001-1, Rev 8-60.
(2) Boly, Ray E. and Tuve, George L., ed., CRC Handbook of Tables for Applied Engineering Science, 1970, page 67.
(3) Abromowitz, M. and Stegun, I. A., ed., Handbook of Mathematical Functions, National Bureau of Standards Applied Mathematics Series 55, Nov 1970, page 879.

B. PROGRAM SPECIFICATIONS

SEE FOLLOWING PAGES.

C. METHODS: The program is part of the CORPS computer system. CORPS is an acronym for Conversationally Oriented Real-Time Program-Generating System. The program is written in time-share G635 Series, FORTRAN IV. It consists of a main program and a subroutine. The main program performs all I/O requirements with the subroutine performing all required calculations. All stops would be unprogrammed, resulting from improper input data.

D. EQUIPMENT DETAILS

The program was developed and is operational on G635, WES, Vicksburg, MS. It is also operational on HIS 66/80, Macon, GA, and Boeing CDC, Seattle, WA.

E. INPUT-OUTPUT

The input variables will be defined at execute time and are the temperature type (F-Fahrenheit, C-Celsius), number of temperatures, and the temperatures. The output will consist of the temperatures as Fahrenheit and Celsius and the corresponding kinematic viscosities (ft^2/sec).

F. ADDITIONAL REMARKS

Complete documentation of this program is available from the Engineer Computer Programs Library, Technical Information Center, WES.

ENG FORM 1 AUG 60 2883 PREVIOUS EDITIONS ARE OBSOLETE.

B. PROGRAM SPECIFICATIONS:

Language: ANSI FORTRAN (FORTRAN IV)

Solution Requirements: The run command

RUN WESLIB/CORPS/H0011, R

Method of Analysis: Known kinematic viscosities at four-degree Celsius intervals are stored in a data statement and then the Lagrange Four Point Interpolation Formula is used to determine the viscosities at the input temperatures.

Core Executive Requirement: G635, 10 K words

Restrictions: Temperatures must be in the 32-100 degree Fahrenheit or 0-38 degree Celsius range.

General Equations:

Conversion of Celsius to Fahrenheit or Fahrenheit to Celsius

$$F = \frac{9C}{5} + 32 \qquad C = \frac{5(F-32)}{9}$$

where F is degree Fahrenheit and C is degree Celsius

Kinematic Viscosity μ (ft^2/sec)

$$\mu = -\frac{p(p-1)(p-2)}{6} f_{-1} + \frac{(p^2-1)(p-2)}{2} f_o$$

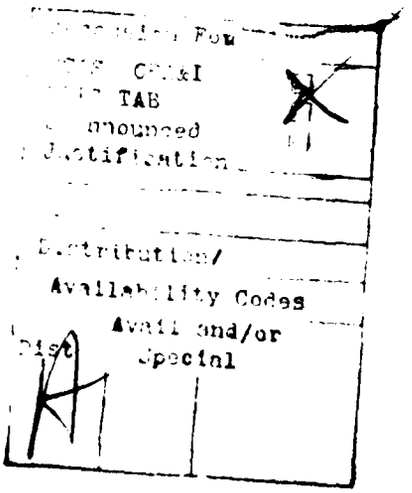
$$-\frac{p(p+1)(p-2)}{2} f_1 + \frac{p(p^2+1)}{6} f_2$$

where f_i, for $i = -1, 0, 1$ and 2 are known viscosities with f_o being the known viscosity at the nearest temperature $\leq$ the given temperature and p is the ratio of the difference between the given

temperature and the temperature at f_o to the difference between the temperatures at f_1 and f_o.

Range of Quantities: For temperatures in the 32-100°F or 0-38°C range; kinematic viscosities will be between 1.922×10^{-5} and 7.35×10^{-6} ft^2/sec.

Accuracy: The kinematic viscosity is computed to four significant figures as interpolated from data of the same precision at 4°C intervals obtained from reference (2).



REF: ER 1110-1-10-ENGINEERING AND DESIGN - Engineering Computer Program Library Standards and Documentation, Appendix B

PART I: ENGINEERING DESCRIPTION

1. PROGRAM NUMBER: 722-F3-R0-00K

2. TITLE: H0011 - Kinematic Vicosity of Water for Temperatures in the 32-100 Degree Fahrenheit Range or 0-38 Degree Celsius Range.

3. REVISION LOG: N/A

4. PURPOSE OF PROGRAM: To compute the kinematic viscosity of water in the 32-100°F or 0-32°C range.

References:

a. HDC Chart 001-1, Rev 8-60.

b. Boly, Ray E. and Tuve, George L., ed., CRC Handbook of Tables for Applied Engineering Science, 1970, page 67.

c. Abromowity, M. and Stegun, I. A., ed., Handbook of Mathematical Functions, National Bureau of Standards Applied Mathematics Series 55, Nov 1970, page 879.

5. STEP SOLUTION:

a. The required inputs, temperature type (F-Fahrenheit, C-Celsius), number of temperatures, and the temperatures are entered and subroutine H0011 is called.

b. Temperature conversions are performed.

c. The viscosity f_o at the nearest temperature $\leq$ the given temperature is determined from the data statement of known viscosities. The viscosities f_{-1}, f_1 and f_2 are then determined.

d. The ratio p, the difference between the given temperature and the temperature at f_o to the difference of the temperatures at f_1 and f_o is calculated.

e. The kinematic viscosity is determined using the Lagrange Four Point Interpolation Formula.

f. The output, the temperatures as Fahrenheit and Celsius and the corresponding kinematic viscosity, is returned to the main program for appropriate I/O operations

6. ACCURACY: The kinematic viscosity is computed to four significant figures as interpolated from data of the same precision at 4°C intervals obtained from reference (b).

7. REMARKS:

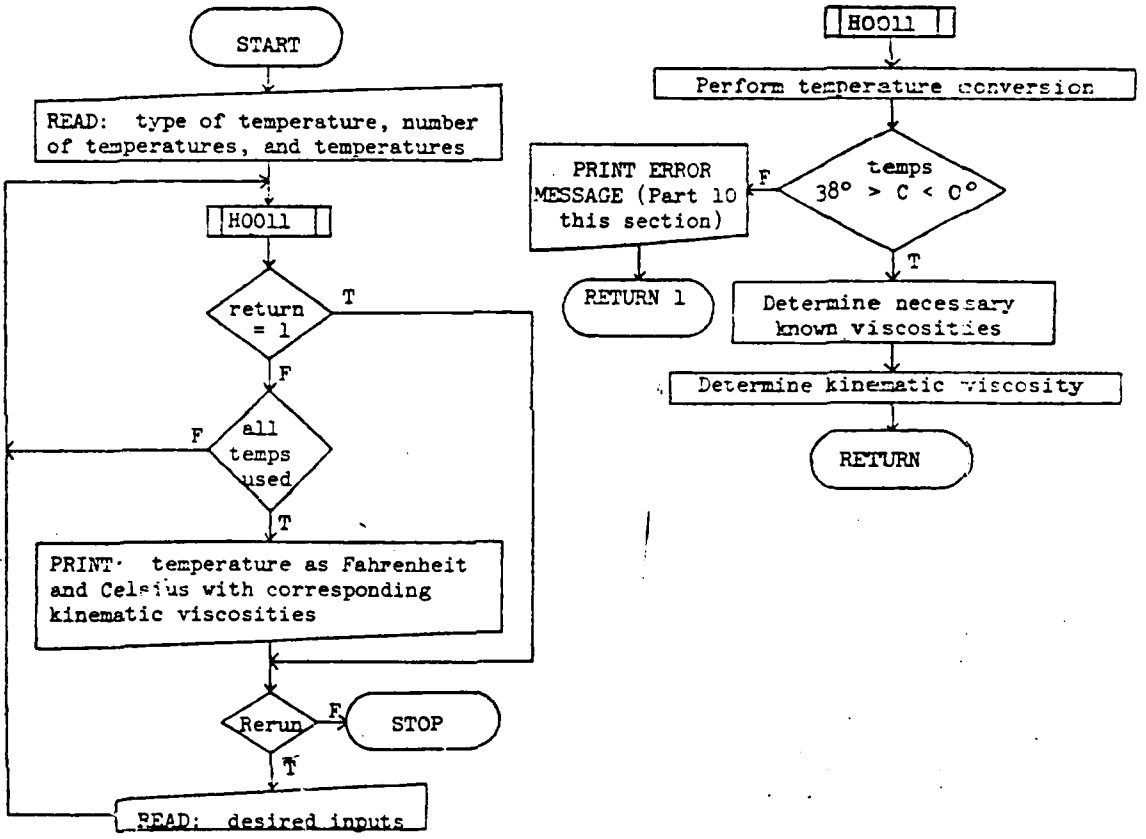
a. Temperatures must be in the 32-100°F or 0-38°C range

b. Kinematic viscosities will be between 1.922×10^{-5} and 7.35×10^{-6} ft^2/sec.

PART II: COMPUTER FUNCTIONAL DESCRIPTION

1. REVISION LOG: N/A

2. FUNCTIONAL FLOW CHART:



3. EQUIPMENT AND OPERATING SYSTEM: The program was developed on a G635 time-share system in which input/output equipment consisted of a Model 33 remote teletype.

4. INPUT REQUIREMENTS: All input is entered via the user's time-share terminal device in free field format. The cues and reads for input are performed in the main program. Since all calculations are done in subroutine H0011, all required I/O arguments for the subroutine are passed via the CALL statement. The calling sequence for the subroutine is:

$$\text{CALL H0011}(arg_1,\ldots,arg_4,\$N)$$

where:

arg_1 - given temperature, degrees (either F or C)

arg_2 - type of temperature, F or C

arg_3 - temperature, °C

arg_4 - kinematic viscosity, ft^2/sec

$N - N is a statement number in the main program for the non-standard return due to temperature < 0°C or > 38°C.

Arguments 1, 3, and 4 are floating point, argument 2 is character, and N is integer. Arguments 1 and 2 are the inputs. If argument 1 is entered as °C, it will be returned as °F with argument 3 as the corresponding °C. Argument 4 is the output value of the kinematic viscosity. N is a STATEMENT NUMBER in the CALL of the main program which directs return from the subroutine to that STATEMENT NUMBER in the main program.

5. SECONDARY STORAGE INPUT FORMAT: None

6. INPUT DATA DESCRIPTION: The following names are used for input variables in program H0011.

N	- number of temperatures	
TEMP	- temperature, degrees (either F or C)	(arg_1)
IDEG	- character, type of temperature, F for °F, C for °C	(arg_2)

7. OUTPUT DATA DESCRIPTION: The following names are used for the output variables in program H0011.

TEP	- temperature, °C	(arg_3)
VISCOS	- kinematic viscosity, ft^2/sec	(arg_4)

If the input TEMP is entered as °C, it will be returned from subroutine H0011 as °F with the output TEP as the corresponding °C.

8. PROGRAM ERROR MESSAGE: The following is an example of the error message printed from subroutine H0011 if TEMP < 0°C or > 38°C.

TEMP OF 120.50 DEG NOT IN GIVEN RANGE

Return is to the statement number N in the main program as described in (4) of this section.

9. VARIABLE DEFINITIONS:

HFILE	- 5 character alphanumeric program name; passed to WESLIB count routine HACCT
LQZ	- equal 1, all input cues and reads are performed; equal 2, call WESLIB routine RERUN for entering only desired input
LQX	- equal 1, print instructions from RERUN; equal 3, no print
JKL	- direct return from RERUN to desired input read

KKK - number of input variables

IDEG - character, type of temperature, F for °F, C for °C

N - number of temperatures

NPOS - position in DATA statement of the viscosity at the nearest temperature $\leq$ the input temperature

TO - temperature at NPOS, °C

P - ratio of the difference between the input temperature and TO to the difference of the temperature between NPOS + 1 and TO

TEMP - given temperature, degrees (either F or C)

TEP - temperature, °C

V - stored known kinematic viscosity, ft^2/sec

VISCOS - kinematic viscosity, ft^2/sec

10. EXAMPLE CASE: Determine the kinematic viscosity of water for 6 given temperatures.

a. Input: Type of temperature (IDEG) = C

Number of temperatures (N) = 6

Temperatures (TEMP) = 5, 10, 15, 20, 25, 30

b. Output:

```
INPUT  H0011 - KINEMATIC VISCOSITY OF WATER IN THE 32-100 DEG-F
               OR 0-38 DEG-C RANGE

AA-ENTER THE NUMBER OF TEMPERATURES FOR WHICH THE KINEMATIC
VISCOSITY IS DESIRED;NUMBER MUST BE < OR = 25
=6
AB-ENTER TEMPERATURE TYPE;F=FAHRENHEIT;C=CELSIUS
=C
AC-ENTER THE  6 TEMPERATURES SEPARATED BY COMMAS
=5,10,15,20.5,25,30


OUTPUT  H0011 - KINEMATIC VISCOSITY OF WATER IN THE 32-100 DEG-F
                OR 0-38 DEG-C RANGE

      TEMP          KIN VIS
 DEG-F     DEG-C    FT**2/SEC
 41.00      5.00    0.1634E-04
 50.00     10.00    0.1407E-04
 59.00     15.00    0.1226E-04
 63.90     20.50    0.1067E-04
 77.00     25.00    0.9608E-05
 86.00     30.00    0.8618E-05

RERUN OR STOP
=STOP
```

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering and Computer Program Library Standards and Documentation, Appendix C

PART III: FILE DOCUMENTATION

1. REVISION LOG: N/A

2. TITLE: H0011 - Kinematic Viscosity of Water for Temperatures in the 32-100 Degree Fahrenheit Range or 0-38 Degree Celsius Range.

3. SOURCE LISTINGS: See pages 9-11.

4. NUMERICAL AND LOGICAL ANALYSIS: Known kinematic viscosities at four degree Celsius intervals are stored in a data statement. The Lagrange Four Point Interpolation Formula is used to determine the viscosities at the input temperatures.

5. SUBROUTINES NOT DOCUMENTED IN ABSTRACT: None

6. MISCELLANEOUS: The program is part of a Conversationally Oriented Real-Time Program-Generating System (CORPS). The program is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA. The source listing on page 9 contains the first line run command for H0011 and its brief. The first line run command runs the binary H0011B of the source listing on pages 10 and 11 (the Fortran listing of program H0011) and attaches the support files RERUN and HACCT.

```
0001*#RUN WESLIB/CORPS/H0011B,R;WESLIB/RERUN,R;WESLIB/HACCT,R
0800 58THIS PROGRAM COMPUTES THE KINEMATIC VISCOSITY OF WATER FOR
0810 59TEMPERATURES IN THE 32-100 DEGREE FAHRENHEIT OR 0-38 DEGREE
0820 63CELSIUS RANGE. THE REQUIRED INPUTS ARE THE TYPE OF TEMPERATURE,
0830 56EITHER FAHRENHEIT OR CELSIUS AND THE TEMPERATURE. OUTPUT
0840 61CONSIST OF THE TEMPERATURE AS FAHRENHEIT AND CELSIUS,PLUS THE
0850 34CORRESPONDING KINEMATIC VISCOSITY.
0999*06FINISH
```

```
00001*#RUN *=;/CORPS/H0011B(NOGO)
10000 CHARACTER HFILE*5,IDEG*1
10010 DIMENSION TP(25)
10020 HFILE=5HH0011
10030 LQZ=1;LQX=1
10040 15000 PRINT 10006
10050 10006 FORMAT(/"INPUT  H0011 - KINEMATIC VISCOSITY OF WATER IN THE "
10060&2-100 DEG-F"/16X,"OR 0-38 DEG-C RANGE"//)
10080 CALL HACCT(HFILE)
10090 GO TO(15003,15017),LQZ
10100 15003 PRINT 15004
10110 15004 FORMAT("AA-ENTER THE NUMBER OF TEMPERATURES FOR WHICH THE KI
10115&NEMATIC"/"VISCOSITY IS DESIRED;NUMBER MUST BE < OR = 25")
10120 15005 READ,N
10130 GO TO(15007,15017),LQZ
10140 15007 PRINT 15008
10150 15008 FORMAT("AB-ENTER TEMPERATURE TYPE;F=FAHRENHEIT;C=CELSIUS")
10160 15009 READ,IDEG
10170 IF(IDEG.EQ.1HF.OR.IDEG.EQ.1HC) GO TO 15012
10180 PRINT,"ANS MUST BE F OR C;RE-ENTER";GO TO 15009
10190 15012 GO TO(15013,15017),LQZ
10200 15013 PRINT 15014,N
10210 15014 FORMAT("AC-ENTER THE ",I2," TEMPERATURES SEPARATED BY COMMAS
10215&")
10220 15015 READ,(TP(I),I=1,N)
10230 GO TO(15020,15017),LQZ
10240 15017 KKK=3
10250 CALL RERUN(KKK,LQX,JKL)
10260 GO TO(15005,15009,15015,15020),JKL
10270 15020 PRINT 15021
10280 15021 FORMAT(//"OUTPUT  H0011 - KINEMATIC VISCOSITY OF WATER IN TH
10290&E 32-100 DEG-F"/17X,"OR 0-38 DEG-C RANGE"//7X,"TEMP",9X,"KIN VIS"
10300&/"  DEG-F    DEG-C   FT**2/SEC")
10310 DO 15027 I=1,N
10320 TEMP=TP(I)
10330 CALL H0011(TEMP,IDEG,TEP,VISCOS,$15027)
10340 PRINT 15028,TEMP,TEP,VISCOS
10350 15027 CONTINUE
10360 15028 FORMAT(F7.2,F9.2,3X,E10.4)
10370 LQZ=2
10380 CHARACTER ZZZZZZ*2
10390 16000 PRINT 16002
10395 16002 FORMAT(/"RERUN OR STOP")
10400 READ 16001, ZZZZZZ
10410 16001 FORMAT(A2)
10420 IF(ZZZZZZ.EQ.2HRE) GO TO 15000
10430 IF(ZZZZZZ.EQ.2HST) GO TO 20000
10440 PRINT,"ERROR *** RETYPE"
10450 GO TO 16000
10460 20000 STOP
```

```
10470 END
11000 SUBROUTINE H0011(TEMP,IDEG,TEP,VISCOS,*)
11010 CHARACTER IDEG*1
11020 DIMENSION V(13)
11030 DATA V/2.22E-5,1.922E-5,1.686E-5,1.491E-5,1.33E-5,1.194E-5,
11040&1.08E-5,9.829E-6,8.993E-6,8.269E-6,7.636E-6,7.08E-6,6.589E-6/
11050 IF(IDEG.EQ.1HC) TEP=TEMP
11060 IF(IDEG.EQ.1HC) TEMP=9.*TEP/5.+32.
11070 IF(IDEG.EQ.1HF) TEP=(TEMP-32.)*5./9.
11080 IF(TEP.GE.0..AND.TEP.LE.38.) GO TO 10110
11090 IF(IDEG.EQ.1HF) PRINT 10090,TEMP,IDEG
11100 IF(IDEG.EQ.1HC) PRINT 10090,TEP,IDEG
11110 10090 FORMAT("TEMP OF ",F6.2," DEG-",A1," NOT IN GIVEN RANGE")
11120 RETURN 1
11130 10110 NPOS=TEP/4+2
11140 T0=NPOS*4.-8.
11150 IF(T0-TEP) 10150,10140,10140
11160 10140 VISCOS=V(NPOS);RETURN
11170 10150 P=(TEP-T0)/4.
11180 VISCOS=V(NPOS-1)*(P-P*P)*(P-2.)/6.+V(NPOS)*(P*P-1.)
11190&*(P-2.)/2.+V(NPOS+1)*(2.*P-P*P)*(P+1.)/2.
11200&+V(NPOS+2)*(P*P*P-P)/6.
11210 RETURN
11220 END
```